A CYTOTAXONOMICAL STUDY ON SOME FORMOSAN LILIACEAE [3]

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Abrtract: The root-tips of 14 species belonging to 9 genera and 6 tribes of Liliaceae (Hutchinson, 1959) have been examined in order to observe their somatic chromosomes. A total of 7 taxa are reported here for the first time. The somatic cells of *Disporum shimadai* have 2n=16, which is reported from Taiwan as a new number.

The basic numbers and karyotypes of the genera *Aspidistra* (X=18) and *Campylandra* (X=19) are different from each other, and this is correlated with their differences in external features. It is suggested that the genus *Campylandra* should be excluded from the tribe Aspidistreae.

The karyotypes of *Aspidistra* and *Peliosanthes* are almost identical. It is possible that these two genera may have been derived from a common ancestor.

Possibly a new taxon of *Aspidistra* has been collected from Mt. Ta-wu, it differs from other species in its karyotype as well as in its external morphology. It needs fruther study.

In the present study, there are found to be only two species of *Peliosanthes* instead of three in Taiwan, these are *P. arisanensis* Hay. and *P. kaoi* Ohwi.

INTRODUCTION

No comprehensive taxonomical study has yet been made on the liliaceous plants of Taiwan, Liu & Ying (1970) have studied a part of these plants based mainly on herbaium material.

The cytological studies of McKelvey and Sax (1933) made a great contribution to the systematics of the monocots. They studied the chromosomes of the liliaceous families and revealed many foundamental facts for the reclassification of the family. Up to now, the plants of the Liliales are still one of the incompletely known groups and so is a very troublesome group for taxonomists. Extensive approaches have been made on this monocot family and various methods have been introduced to enable one to get a better understanding of its phylogeny. One of these methods is a study of cytology, and although it has limitations, the work of the McKelvey and Sax has been like a spotlight, encouraging students of taxonomy to apply cytology as a tool for the classification of the liliaceous plants.

The cytological studies of some Taiwan liliaceous plants have been reported by Chuang *et al.* (1962), Chao (1963) and Hsu (1967, '71, '72). The karyotype analysis of the genus *Disporum* and a cytotaxonomical study of the tribe Ophiopogoneae have been made by Chuang *et al.* (1962), and Hsu (1971). The present observations are an extension of their previous studies. Extensive studies on the somatic chromo-

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somes are all based on root-tips. Plants collected in the field were cultivated in our experimental gardens, Department of Botany, NTU., Taipei.

In the course of the present study, the junior author is indebted to the members of the Laboratory of Grasses, for their assistance both in collection materials, cultivations and countless other ways, also to Dr. C. C. Chen of the Research Institute of Agriculture, for his valuable technical suggestions.

MATERIALS AND METHOD

All plants used in this study have been carried from their native habitats and sown in pots, cultvated in the shade house of the Department of Botany, NTU. The cytological technique follows the procedure of Chen (1969):

1. The root tips were cut from the plant and pretreated in 0.002M 8-hydroxyquinoline (18–20°C) or 0.1% colchcine for 6–8 hrs.
2. They were fix overnight in a alcohol (95–100%) and glacial acetic acid solution 3: 1 (freshly prepared).
3. Washed in 70% alcohol and stored in the same at 4°C in a refrigerator.
4. Hydrolyzed in 1N HCl at 60°C for 8–10 min.
5. Rinsed in 3 changes of distilled water for 2–3 minutes each time.
6. Stained for 10–30 min. in a leuco-basic fuchsin solution.
7. Treated with 5% pectinase for 1–2 hrs.
8. Transferred to 45% acetic acid for 10 min. to clear the cytoplasm.
9. Squashed the meristematic region in one drop 45% acetic acid on the slide, the extraneous tissue was discarded and then a cover glass was added and pressure exerted.
10. The slide was then checked under a microscope, if the chromosome preparation was satisfactory, it was sealed with paraffin wax.

For the observation of the karyotype, the chromosomes of the somatic metaphase were examined with an aid of a microscope under 800X and 2,000X magnifications and microphotographs were taken.

The length of each chromosome was measured from end to end excluding the region of the centromere and secondary constriction. The satellate was excluded too, if it was too small. When the arm was curved, it was measured along the curve.

The relative length of the chromosome is indicated by the ratio of the length of each chromosome to the mean value of the length of the total chromosomes, When the ratio is between 1.01 to 1.25, the chromosome is considered a large chromosome (L), when the ratio is between 0.75 to 1.00, it is considered medium (M), and when the ratio is lesser than 0.75, it is a small (S) chromosome.

The chromosome morphology is determined by its centromere position; that is by their arm ratio (long arm/ short arm) and classified into 4 categories: (1). metacentric chromosomes (m) have an arm ratio of 1:1; (2). submetacentric chromosomes (sm) have an arm ratio more than 1:1 and less than 3: 1; (3). subtelocentric chromosomes (st) have an arm ratio equal to 3: 1 or more; (4). telocentric chromsomes (t) have an arm ratio of 1: 0.

For the construction of a karyotype, chromosomes were cut from an enlarged photograph and matched in pairs by their length and morphology. Each pair was given a number in a serial order, according to their decreasing length.

In discussing the symmetry of the karyotype the terms symmetrical of asym-

metrical were used, based on the definition made by Stebbins (1970), and the degrees of the asymmetry as classified by the same author in Table 1. The symmetrical karyotype have the chromosomes of metacentric or submetacentric type and all the chromosomes have nearly equal sizes. When the chromosomes are subtelocentric or telocentric and size of chromosomes becomes different, the karyotype is called asymmetrical. It has been said that the asymmetrical karyotype is more advanced than symmetrical ones.

Table 1. The degree of asymmetry of the karyotype

Longest chromosome / Shortest chromosome	% of arm ratio >2:1			
	0.00	0.01-0.50	0.51-0.99	1.00
<2:1	1A	2A	3A	4A
2:1-4:1	1B	2B	3B	4B
>4:1	1C	2C	3C	4C

RESULT AND DISCUSSION

Table 2 is a brief summary of our present cytological study of the Formosan Liliaceae. In Table 2 the genera and species are arranged alphabetically. An asterisk(*) indicates the first reports of the chromosome count. The tribe name used here is as defined by Hutchinson (1959). Systematic suggestions based on the karyotype study are discussed as follows:

I. Tribe Tulipeae Hutch.

Genus **Lilium** Tourn. et Linn.

In the tribe Tulipeae only the representative genus, *Lilium* is found in Taiwan. According to Liu & Ying (1970), there are 4 species of *Lilium* native to Taiwan. They are: *L. callosum* Sieb. et Zucc., *L. formosanum* Wall., *L. longiflorum*, and *L. speciosum* Thunb. var. *gloriosoides* Bak. Among these 4 species, *L. formosanum* has the widest ecological amplitude; it is distributed from sea level to 3,000 m in altitude. The next is *L. longiflorum*, which is distributed in the northern part and northeastern littoral hillsides, to Green Island and Botel Tobago, and from sea level up to about 600 m. *L. speciosum* Thunb. var. *gloriosoides* Bak. is an endemic species found only in the northern part of the Island. *L. callosum* is only known from Miaoli County.

Key to the native species of *Lilium*

1. Flowers trumpet-shaped:
   2. Perianth white inside, with brownish-purple strips outside.....*L. formosanum*
   2. Perianth white, both inside or outside.....*L. longiflorum*
1. Flowers not trumpet-shaped; perianth segments reflexed, bell-shaped:
   2. Perianth yellow to scarlet.....*L. callosum*
   2. Perianth white with deep red spots and papillae.....*L. speciosum* var. *glorioscides*

Sato (1932) and Stewart (1974) investigated many species belonging to the genus *Lilium*, and found that most of them have 2n=24 chromosomes. Their basic karyotype consists of two large pairs of chromosomes with metacentric or submetacentric centromeres. The karyotypes of *L. callosum*, *L. formosanum*, *L. longiflorum* and

Table 2. A summary of cytological data on Taiwan Liliaceae.*

Taxon	Voucher	Locality	2n	Previous counts & authority
ASPIDISTRA				
attenuata	Hsu 3380	A-li-shan	36	*
daibuensis	Hsu, s. n.	Nan-jien-shan	36	2n=36, Hsu (1971)
mushaensis	Chang 2234	Wu-sho	36	*
sp.	Hsu, s. n.	Ta-wu-shan	36	*
CAMPYLANDRA				
watanabei	Hsu 800	Shih-yuen-ya-kou	38	*
DISPOROPSIS				
arisanensis	Hsu 12664	Nan-chuang	40	2n=40, Sato(1942)
	Lai 6694	Pei-chia-tien-shan	40	
	Chang 1083	Yuen-Yang Lake	40	
DISPORUM				
kawakamii	Chang 2093	Nan-feng-shan	16	n=8, Chuang et al. (1962); 2n=16, Chao et al. (1963) 2n=32, Hsu (1971)
shimadai	Chang 1694	Ta-tun-shan	14, 16*	2n=14, Chao *et al.* (1963)
	Chang 2329	Wu-lai	16	
	Lee, s. n.	Ho-ping-tao	16	
LILIUM				
speciosum var. gloriosoides	Hsu 6603	Shih-ting	24	*
PELIOSANTHES				
arisanensis	Chang 2095	Nan-feng-shan	36	2n=36, Sato (1942)
kaoi	Chang 1524	Teng-chih	36*	n=17, Hsu (1971)
POLYGONATUM				
cyrtenma	Chang 1697	Ta-tun-shan	22	*
SCILLA				
scilloides	Hsu 12232	Wan-li	34	See Darlington & Wylie; Cave; Orndoff.
SMILACINA				
formosana	Chang 2043	Ta-pa-chien-shan	36	2n=36, Chuang *et al.* (1962)
	Chang 2338	A-li-shan	36	

*An asterisk indicates that the chromosome number appears here for the first time.

several varieties of *L. speciosum* were studied by them.

In the present study, *Lilium speciosum* var. *gloriosoides* Baker was critically investigated. The materials were collected from Shih-ting. The somatic chromosome number of this species is 2n=24. (**Plate I, a**). The karyotype is of the asymmetrical type with 4 distinctly large chromosomes (1-2), 6 sublarge (3-5), 8 medium (6-9), and 6 small (10-12) chromosomes. The 4 large chromosomes have metacentric or submetacentric centromeres (1 & 2). The 6 sublarge chromosomes have nearly the same size and morphology, but they are all telocentric. In the 8 medium sized chromosomes, 6 are subtelocentric and the other 2 seem to be heteromorphic homologues, one of which has a telocentric and the other a subtelocentric centromere. In the 6 small chromosomes, 4 are subtelocentric and 2 are telocentric. The degree of the asymmetry is of (3B). The karyotype formula may be written as: 2n=24= $2A^{m}+2B^{m}+6C^{\prime}+6D^{\prime}+2E^{\prime-t}+4F^{\prime}+2G^{\prime}$. The chromosome count and karyotype of this variety is a first report.

Sato (1932) reported *L. speciosum* var. *speciosum* and two other varieties grown in Japan. He found that these three taxa have the same karyotype and each has a satellate on one of the largest chromosomes. Stewart (1947) observed 4 varieties of species. Three of the four varieties he investigated had the same karpotype, but the other one had a small difference in its karyotype. The difference in the karyotype is due to the position of the secondary constriction on one of the largest chromosomes. However, in the present observation, the Formosan species do not possess a secondary constriction. It is possible that the difference between the varieties may come from the minute and undistinguishable chromosome invertions and translocations.

II. Tribe Scilleae Hutch.

This tribe has one genus with only one species, *Scilla scilloides* (Lind.) Druce in Taiwan. It is a bulb-bearing species, and its flowers are very similar to those of *Allium*, but they differ in having a racemose inflorescence. Previous counts on the species have shown 2n=34 (Noda, 1967), 2n=35 (Satomi & Ihara, 1963); Haga (1961) reported that individual differences do exist in this species, and one to seven B-chromosomes were found by him.

The present investigation confirms Noda's result. It has the somatic chromosome number of 2n=34. The karyotype is of the asymmetrical type with two large chromosomes, 22 medium chromosomes and 10 small ones. The two large Chromosomes are submetacentric, the medium chromosomes are subtelocentric or telocentric, and the 10 small chromosomes are metacentric or submetacentric, of these 10 the smallest one has a satellate. The degree of the asymmetry is (3B). The karyotype formula may be written as follows:

$2n=34=2L+22M+10S=2A^{\prime m}+2B^{\prime t}+20C^{\prime t}+10D^{\prime m}$ (**Plate I, b**).

The karyotype of *S. scilloides* is similar to *S. chinensis* and *S. japonica* (Sato, 1935). The latter two species have subtelocentric chromosomes and metacentric chromosomes, while the former has more subtelocentric chromosomes. Sato (1935) suggested that *S. scilloides* may have come from an amphidiploid origin. That is to say, the species is a hybrid derived from two species which have 2n=16, and 2n=18. Satomi & Ihara (1963) made a cytological study on *S. scilloides* and they considered that its karyotype was composed of two genomes, namely A and B. A is the genome of 2n=16, and B 2n=18. It seems possible that *S. scilloides* found in Taiwan also had an amphidiploid origin.

III. Tribe Polygonateae Hutch.

The external features of the plants belonging to the tribe Polygonateae look very much alike, their ecological habitat is also uniform, and their pollen morphology is of the same type: i.e. monocolpate elliposoid, scabrate, and their sizes range from 24-26μ×38-66μ×22-36μ (Huang, 1972). But on the other hand, the morphology of their rhizomes show great differences among the different genera and this provides a promising key character. This group of plants grow in wet and foggy forests ranging from 1,000m to 3,500m in altitude. They are perennial herbs with developed rhizomes A new leafy shoot comes from the rhizome each spring and flowers. In this Island, there are four genera belonging to this tribe. The genera can be identified by the following key:

1. Rhizomes short, tuberous, similar to ginger.....3. *Polygonatum*
1. Rhizomes creeping, not tuberous
   2. Aerial stem and rhizome of same or similar structure.....1. *Disporopsis*
   2. Aerial stem and rhizome decidedly different in structure.
      3. Rhizome very slender, white, long creeping; roots fibrous, tufted as in *Ophioglossum*.....2. *Disporum*
      3. Rhizome thick, brown, bearing thin scattered roots.....4. *Smilacina*

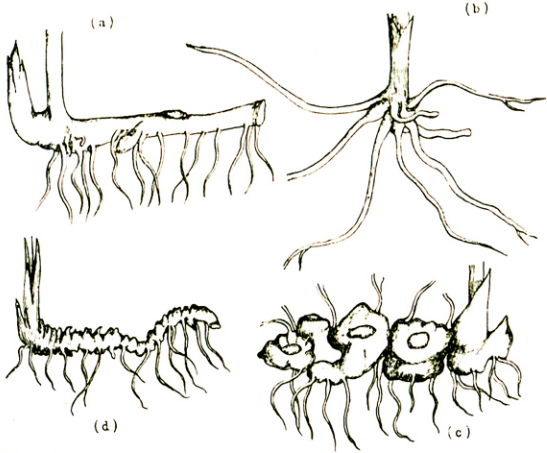


Fig. 1. The morphology of the rhizomes of Polygonateae: (a). *Disporopsis;* (b). *Disporum* (c). *Polygonatum;* (d). *Smilacina.*

Key to the genera and the species of tribe Polygonateae

1. Inflorescence terminal:
   2. Inflorescence in a raceme or panicle; perianth white; anther dorsifixed ..... *A. Smilacina formosana*
   2. Inflorescence in an umbelliform raceme; perianth base saccate; anther basifixed ..... 2. *Disporum*
      3. Flowers yellow; leaves lanceolate, sessile or nearly so ..... *D. shimadai*
      3. Flowers white, apex of the perianth greenish; leaves ovate-lanceolate to ovate, pedicellate ..... *D. kawakamii*
1. Inflorescence axillary; flowers nodding:
   2. Corona present; flowers axillary, 1-2 from a leaf-base, pedicellate but without peduncles ..... 1. *Disporopsis arisanensis*
   2. Corona absent; flowers both with pedicels and peduncles ..... 3. *Polygonatum*
      3. Flowers white, greenish at apex, 1.5-2.5cm long; pedicel 0.5-1.5cm long; peduncle 1.5-4cm long; flowers 2 to several ..... *P cyrtenma*
      3. Flower yellow, 0.5-1.5cm long; pedicels and peduncles shorter; flowers 2-3 ..... *P. alte-lobatum*

Several cytotaxonomical papers on the tribe Polygonateae have been contributed by Hasegawa (1932), Sato (1942) and Therman (1950, '56). In the present study, the karyotypes of five species belonging to these four genera have been worked out.

1. Genus **Disporopsis** Hance

Only one species, *Disporopsis arisanensis* Hay., of this genus is found in Taiwan. It usually grows at altitudes ranging from 1,500 and 2,500 but sometimes grows along streams down to about 400m above the sea level. Size of these plants show a wide range. For example, plants growing by Yuan-Yang Lake and at Pei-cha-tien-shan usually have stems 15-20cm high, while those growing at Nan-chuang have stems 2-3 times longer. The leaves and fruits are also larger in the Nan-chuang population. However, the epidermal pattern and karyotype of these populations are the same.

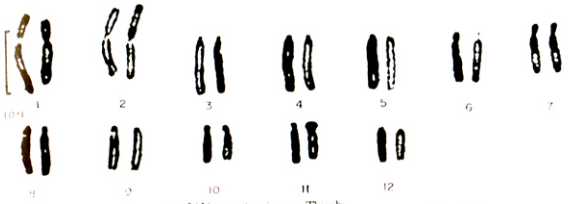
This species has the somatic number of 2n=40. The karyotype is symmetrical. These 40 chromosomes change their size gradually. The largest two pairs have submetacentric centromeres, and the smallest two pairs have subtelocentric centromeres. The degree of the asymmetry is (1B). Its karyotype formula may be written: 2n=40=16L+24S. (**Plate I, c**). Sato (1942) reported 2n=40 for this species, he described the karyotype as 2L+2M+36S, and suggested this species a diploid species. The Thailand species *Disporopsis longifolia* Craib. reported by Larsen (1966), has the chromosome number of n=20, 2n=40.

In the Chromosome Atlas (Darlington & Wylie, 1955), the basic number of this genus was suggested to be X=10. The present results confirm the number of X=10, and further more indicates that *D. arisanensis* is a tetraploid species.

Nakai (1936) excluded the genus *Disporopsis* from the tribe Polygonateae and established a new tribe, Disporopsideae, which included the family Convollariaceae. Nakai's treatment is strongly supported in this investigation.

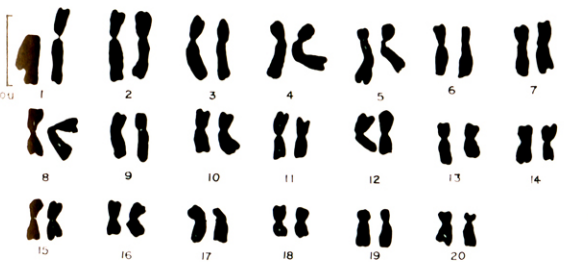
2. Genus **Disporum** Salisb.

Chao *et al.* (1963) studied the meiosis of the pollen mother cells as well as the somatic chromosomes for the genus *Disporum* of Taiwan. The present results closely agree with theirs. Two species, *D. kawakamii* Hay. and *D. shimadai* Hay. were under critical observations.



a. *Lilium speciosum* Thunb. var. *gloriosoides* Bak. 2n = 24

b. *Scilla scilloides* (Lindl.) Druce 2n = 34



c. *Disporopsis arisanensis* Hay. 2n = 40

d. *Disporum kawakamii* Hay. 2n = 16

Plate I. Karyotypes of *Lilium speciosum* Thunb. var. *gloriosoides* Bak., 2n=24 (**a**); *Scilla scilloides* (Lindl.) Druce, 2n=34 (**b**); and *Disporopsis arisanensis*, Hay., 2n=40 (**c**); *Disporum kawakamii* Hay., 2n=16(**d**).

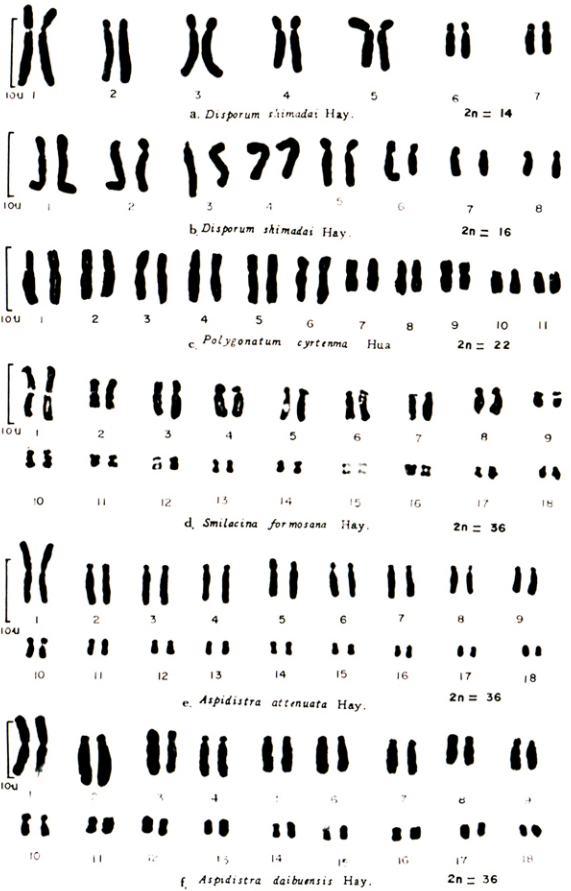


Plate II. Karyotypes of *Disporum shimadai* Hay., 2n=14 (**a**); 2n=16 (**b**); *Polygonatum cyrtenma* Hua, 2n=22 (**c**); *Smilacina formosana* Hay., 2n=36 (**d**); *Aspidistra attenuata* Hay., 2n=36 (**e**); *Aspidistra daibuensis* Hay., 2n=36 (**f**).

(1). **Disporum kawakamii** Hay. The somatic chromosome number of this species is 2n=16. The karyotype is of the asymmetrical type with three groups of chromosomes: one pair of large chromosomes with telocentric centromeres, three pairs of medium chromosomes with subtelocentric centromeres, and four pairs of small chromosomes of which three pairs have subtelocentric and one pair has submetacentric centromeres. (**Plate I, d**) From two populations that were investigated by Chao *et al.*, one pair had heteromorphic homologues and meiosis of the pollen mother cells was said to be abnormal. Chao *et al.* suggested that this species be a hybrid. The present result confirms one of the Chaos' populations (S11613). The second pair of chromosome in Plate I, d shows the so called heteromorphic homologues. Hsu (1971) reported 2n=32 from southern Taiwan. This indicates that there may be tetraploid individuals in the species.

(2). **Disporum shimadai** Hay. Chao *et al.* (1963) reported this species has a chromosome number of 2n=14. However, in the present study, both numbers 2n=14 and 2n=16 were found in the same root-tip of different cells. Proportionally the cells with 14 chromosomes are more abundent. Meiosis was not investigated in this study, and the occurence of 2n=16 leaves an incompletely understood problem. The karyotypes observed were: $2n=14=2L+8M+4S=2A''+2B''+2C''+3D''+E'''+4F''$. (**Plate II, a**). The 14 chromosomes are of three groups: two large, eight medium and four small. The two large chromosomes are subtelocentric. The eight medium chromosomes, seven have subtelocentric, and one a subtelocentric centromeres, and no heteromorphic homologues were seen. On the other hand, those cells having 2n=16, had two extra chromosomes of a medium size, and a small chromosome with a subtelocentric centromere (**Plate II, b-6**). It is possible that *D. shimadai* is also a hybrid. The chromosome number of 2n=16 for *D. shimadai* is a first report.

3. Genus **Polygonatum** (Tourn.) Adans.

The basic chromosome numbers found in this genus are X=9, 10, 11 and 14 (Darlington & Wylie, 1955; Cave, 1956, '64; Ornduff, 1965-70). Two species of *Polygonatum* have been reported from Taiwan, of which the karyoptype analysis was made on *P. cyrtonema* Hua.

This species has a somatic chromosome number of 2n=22, of which three groups of chromosomes can be identified, i. e. 12 large, six medium, and four small chromosomes. Of the 12 large chromosomes, four have the arm ratio of 3:2 to 4:3, and eight have the arm-ratio of 2:1; the six medium chromosomes all are metacentric ones. The four small chromosomes are subtelocentric. The degree of the asymmetry is of (1B). The karyotype may be expressed as: 2n=22=12L+6M+4S (see **Plate II, c**).

4. Genus **Smilacina** Desf.

In this genus only one species, *S. formosana* Hay., is found in Taiwan. The somatic chromosomes of this species is 2n=36, and was reported by Chuang (1962). A noteworthy cytotaxonomical contribution on the genus has been made by Kawano & Iltis (1966).

The present observations on the root-tip cells of the species is 2n=36. The karyotype is composed of chromosomes: (a). two large chromosomes with metacentric centromeres; (b). 14 medium chromosomes, of which two have metacentric centromers, the other two have submetacentric centromeres; (c). the 20 small chromosomes are submetacentric or metacentric, among them one pair has a satellate (**Plate II, d-10**). The karyotype is: 2n=2L+14M+20S (**Plate II, d**), and

the drgree of the asymmetry is of (2C). Our results agree with Chuang's. It is interesting that the karyotype of *S. formosana* is almost the same with *S. racemosa* var. *racemosa* of North America studied by Kawano & Iltis. Furthermore, among the 12 taxa investiated by them, high polyploids (2n=8x=72; 2n= 16x=144) were found. They concluded that all *Smilacina* species are remarkably uniform in the basic karyotype and suggested that the genus is one of the disjunct Arcto-Tertiary elements between Old and New World. Morphologically they are differentiated and adapted to cloud forest habitats. Stebbins (1967) called these plants with disjunctive distributions "vicarious species"

IV. Tribe Aspidistreae Hutch.

The tribe Aspidistreae defined by Hutchinson is a group of perennial herbs with rhizomes. The aerial stems are very short or stemless and the leaves are radical or come from the rhizome. The inflorescence of this group is on dense bracteate spikes or solitary and the perianth is 4-3-merous. They are united at the base, campanulate or broadly tubular. Stamens are 6 or 8, inserted on the perianth-tube and the ovary is 4-3-celled. We have two genera of these plants in Taiwan, and they can be differentiated by the following key:

1. Flower solitary; leaves long petiolate ..... 1. *Aspidistra*
1. Flowers in dense bracteae spikes; leaves sessile ..... 2. *Campylandra*

1, Genus **Aspidistra** Ker-Gawl

There are three species of *Aspidistra* in Taiwan, namely: *A. attenuata*, *A. daibuensis*, and *A. mushaensis*. The vegetative parts of these three species all look alike, but the flowers and fruits are seldom seen. It is very difficult to distinguish them merely by their vegetative parts. Our materials were collected from their type localities and checked against the original description.

(1). **Aspidistra attenuata** Hay. Specimens collected from the Tung-pu Hotspring possess thick rhizomes and coriaceous leaves with long petioles (30-40 cm long). The blades are about 80 cm long by 8 cm wide, acute at the apex and acuminate at the base. The flower is solitary with a short stalk of 1.5-2.5 cm long, and is subtended by conspicuous lanceolate, thin bracts. Perianths are 8, brownishpurple in color, and united into a campanulate tube. Stamens are 8.2-2.5 mm long, inserted in the tube, and the stigma is capitate with 2 mm long stalk.

The somatic chromosomes of this species are 2n=36. The karyotype formula may be expressed as follows: $2n=36=2L+16M+18S=2A^{\prime\prime\prime}+6B^{\prime\prime}+2C^{\prime\prime}+4D^{\prime\prime}+4E^{\prime}$ $6F^{\prime\prime\prime}+12G$. (**Plate II, e**) The 36 chromosomes can be arranged in three categories: lage, medium and small: (a). The one pair of large chromosomes possess a metacentric centromere; (b). The 16 medium chromosomes have subtelocentric centromeres, three pairs of them having the arm-ratio of 6:1 one pair with the ratio of 3:1, and the other four pairs with arm-ratios of 6:1, of whicn two pairs of them are medium sized and the other two somewhat smaller; (c). Among the 18 small chromosomes, 6 are somewhat larger, and the other 12 are distinctly smaller with submetacentric or metacentric centromers.

(2). **Aspidistra daibuensis** Hay. Hsu (1967) repoted 2n=36 for this species. The sample for the present cytological study was collected from Nan-jen-shan. It was collected from the edge of a cultivated field. The plant was dwarf in form and the leaves were 30-40 cm long by 5-6 cm wide. The flowers urceolate-campanulate.

The somatic chromosome of this species is 2n=36. The karyotype formula may be written as follows: 2n=36=2L+16M+18S (**Plate II, f**). Its karyotype is exactly

like of *A. attenuata*.

(3). **Aspidistra mushaensis** Hay. A specimen collected from the Lu-shan Hot-spring has coriaceous leaves but they are somewhat thinner than those of *A. attenuata*, and are 30-40 cm long by 5-6 cm wide. This shows the same karyotype as the previous two species with: 2n=36=2L+16M+18S. (**Plate III, a**)

(4). **Aspidistra** sp. A specimen collected from Mt. Ta-wu is a doubtful taxon. It differs from others by its much smaller size and different karyotype. It possesses smaller and narrower leaves with blades 15-20 cm long by 4 cm wide with many white spots on them and has a petiole. The karyotype is: 2n=36=2L+20M+14S (**Plate III, b**). Its karyotype is composed of two large metacentric chromosomes, 20 medium chromosomes with subtelocentric centromeres, and 14 small chromosomes with submetacentric or metacentric centromeres.

Based on the external features and karyoptype, it is possible that this is a new species, however up to now no flowers or fruits have been seen and so needs further study.

The species belonging to the genus *Aspidistra* were mainly identified by Hayata (1912, '10) on the size of their leaves and flowers. The differences between *A. attenuata* and *A. daibuensis* as described by Hayata may be listed as follows:

Character \ Species	*A. attenuata*	*A. daibuensis*
Leaf:	Large, about 125 cm long.	Smaller, about 45 cm long.
Flower:	Floral-tube campanulate.	Floral-tube urceolate; Perianth-segment with 2 keels.

Aspidistra usually grows on the margin of forests as an undergrowth. It is one of the half-shade plants. When it grows in shady places, the leaves are longer, but when it grows in open, sunny places, the leaves become smaller. *A. attenuata* growing on the edge of a forest is tall, with larger leaves. These same plants when grown in a shade house, become smaller. A plant of *A. daibuensis* collected from Nan-jen-shan was taken and cultivated in our shade house, it became much larger than in its original habitat. Therefore, the size of their leaves may not be a reliable character for identification.

As to the floral shape in *A. attenuata*, the field observations as well as the herbarium sheets show that the flowers are attached at the very base of the plant, just above the soil surface, and are campanulate in shape, however when they are dry or faded, they become urceolate, and due to the dehydration of the perianth-tube, the keels become conspicuous.

In short, the genus *Aspidistra* needs further study.

2. Genus **Campylandra** Bak.

In this genus only one species, *Campylandra watanabei* Dandy is reported from Taiwan. It has 2n=38 chromosomes, of the 19 pairs of chromosomes, their change in size is in a gradual series from large to small. There are two pairs of large chromosomes with metacentric centromeres, and two pairs of sublarge chromosomes with submetacentric centromeres; the other 15 pairs are not so easily distinguished by their sizes. In these 15 pairs, only one pair possesses subtelocentric centromeres, the others are metacentric. The degree of the asymmetry is of (2B). (**Plate III, c**)

Sato (1942) studied a related species, *Rhodea japonica*, and also reported 2n=38 chromosomes. The karyotype was also reported to be of the asymmetrical type. The karyotypes of the genera *Campylandra* and *Aspidistra* are very different. The basic number of the former is X=19, and the degree of asymmetry is of type (2C). The gross morphology of these two genera also show dissimilarity. Their differences are listed as following:

Character \ Genus	*Aspidistra*	*Campylandra*
Stem:	Rhizome creeping; scaly.	Rhizome fleshy, without scales.
Leaf:	Petiole conspicuous	Sessile
Inflorescence:	Solitary, stalked, arising from rhizome	Dense terminal spike
Flower:	4-merous, tubular campanulate	3-merous, broadly campanulate

Based on karyotypes and their morphological strutures, it is suggested that *Campylandra* be excluded from the tribe *Aspidisteae*. Nakai (1936) created the tribe Rhodae as a sectien of the family Convollariaceae Link (1829) and placed the genera *Rhodea* and *Camphylandra* in this new tribe. After observing the karyotypes, Sato (1942) has the opinion that *Aspidistra* very different from the plants belonging to Rhodeae, and our results agree with his.

V. Tribe Peliosantheae Hutch.

This tribe contains the single genus, *Peliosanthes*. It is distributed in tropical regions. Three species have been reported from Taiwan, namely *P. arisanensis* Hay., *P. tashiroi* Hay. (1916), and *P. kaoi* Ohwi (1967). Hayata in his Icones Plantarum Formosanarum II separated *P. arisanensis* from *P. tashiroi* and treated them as two new species. He said that these two species were very similar in external features but differed in the number of their floral parts, the former had 6 floral parts, while the latter 5. The holotype of the former was collected at Mt. A-li-shan in January, and the latter was collected but once in the wild and then cultivated in Taipei, it flowered in February. It is possible that those with 5-merous floral parts are abnormal forms, and probably *P. tashiroi* is a cultivated abnormal form of *P. arisanensis*. Such abnormal conditions are often seen in liliaceous plants. In the populations of *Ophiopogon*, for instance, there exist individuals in the field with 5-merous floral parts. The authors have found plants of *P. kaoi* with 4, 5, and 6 floral parts growing on the same plant and this condition is not rare. Therefore the authors favor reducing *P. tashiroi* to a synonym of *P. arisanensis*, Ohwi (1967) discussed this same problem when he described *P. kaoi* as a new species. So we conclude that there are only two species of *Peliosanthes* in Taiwan instead of three. They can be identified by the following key:

1. Leaves larger, blades 15-25 cm long by 5-8 cm wide.....1. *P. arisanensis*
1. Leaves smaller, blades up to 10 cm long by 1.5-2.5 cm wide .....2. *P. kaoi*

The following previous cytological studies have been reported: Sato (1942) reported the karyotype of *P. arisanensis* as 2n=36=2L+2M'+4M+28S. Larsen observed a Thailand species with the same number of 2n=36. Jones & Smith (1967) studied two species, of which both were 2n=36.

The haploid number of n=18 was obtained from PMCs of one species; Hsu (1971) found the PMCs of *P. kaoi* to be n=17. It seems that the basic number of the genus should be X=18.

(1). **Peliosanthes arisanensis** Hay. We found the somatic chromosome number and karyotype be: $2n = 36 = 2L + 2M' + 4M + 28S$. (**Plate III, d**). This confirms Sato's result. The degree of the asymmetry of the karyotype is (2C), with 18 pairs of chromosomes. One pairs of large chromosomes has metacentric centromeres; three pairs of medium chromosomes have subtelocentric centromeres, one of them has a secondary constriction on the long arm;14 pairs of small chromosomes have submetacentric or subtelocentric centromeres.

(2). **Peliosanthes kaoi** Ohwi. This species also has $2n = 36$ number of somatic chromosome, but the karyotype (**Plate III, e**) is somewhat different from *P. arisanensis*. Its karyotype formula may be expressed as follows: $2n = 2L + 4M + 30S$. The degree of the asymmetry is also of (2C), with one pair of longest chromosomes having subtelocentric centromeres, and the 15 pairs of small chromosomes having the subtelocentric or submetacentric centromeres.

The authors found a close relationship between the karyotypes of *Aspidistra* and *Peliosanthes*. The basic chromosome number was $X = 18$, with the somatic chromosome of $2n = 36$. In their karyotypes, each had a large metacentric chromosome and the other components of the karyotype were similar both as to size and morphology, the degree of the asymmetry for all was (2C). Due to the similarity between the karyotypes of *Aspidistra* and *Peliosanthes*, it is suggested that they may have been derived from a common ancestor, but have followed different evolutionary lines. Our studies on *Ophiopogon* and *Liriope* gave the same findings as by Hasegawa (1968) and Sato (1942), and since these groups have vary similar karyotypes, we agree with Engler's classification of including the genera: *Liriope*, *Ophiopogon* and *Peliosanthes* in the tribe Ophiopogonoideae, and we suggest that the genera *Aspidistra* and *Peliosanthes* be included in Ophiopogoneae.

Based mainly on external features, Nakai (1936) placed *Ophiopogon* and *Liriope* in the tribe Ophiopogoneae, *Peliosanthes* in Pelisoantheae, and *Aspidistra* in Aspidistreae. This seems to be a reasonable arrangement and is supported by our studies.

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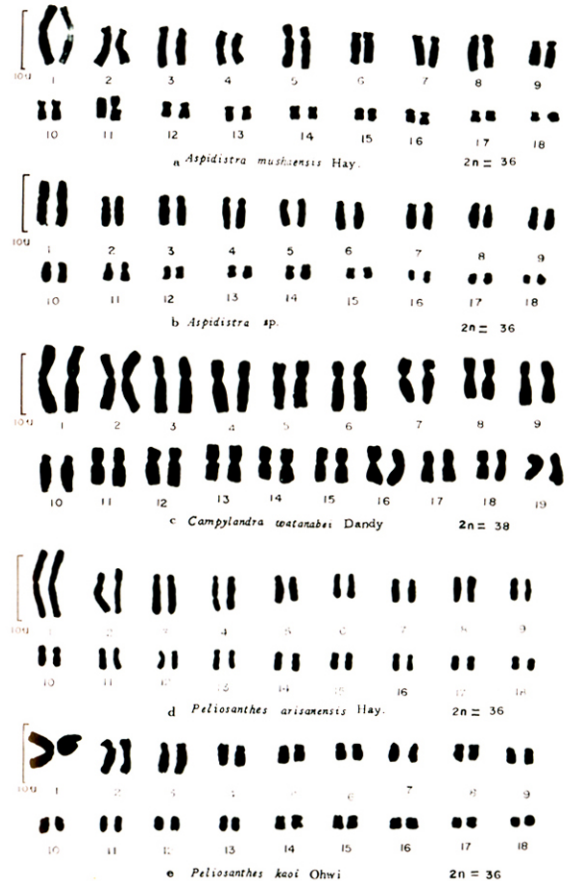

Plate III. Karyotypes of *Aspidistra mushaensis* Hay., 2n=36 (**a**); *Aspidistra* sp., 2n=36 (**b**); *Campylandra watanabei* Dandy, 2n=38 (**c**); *Peliosanthes arisanensis* Hay., 2n=36 (**d**); *Peliosanthes kaoi* Ohwi, 2n=36 (**e**).

Plate IV. Microphotographs showing the somatic chromosomes of a. *Lilium speciosum* var. *gloriosoides*, 2n=24; b. *Disporum shimadai*, 2n=14; c. *Disporum shimadai*, 2n=16; d. *Peliosanthes kaoi*, 2n=36; e. *Campylandra watanabei*, 2n=38; f. *Smilacina formosana*, 2n=36; g. *Disporopsis arisanensis*, 2n=40; h. *Scilla scilloides*, 2n=34; i. *Peliosanthes arisanensis*, 2n=36; j. *Aspidistra attenuata*, 2n=36; k. *Aspidistra mushaensis*, 2n=36; l. *Aspidistra* sp., 2n=36; m. *Disporum kawakamii*, 2n=16; n. *Aspidistra daibuensis*, 2n=36; o. *Polygonatum cyrtonema*, 2n=22.